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54 Artificial intervertebral disc.

57 An artificial intervertebral disc (10) comprising a  
 pair of end bodies (1) which are provided, on their  
 outer surfaces, with apatite layers (4) and a medical  
 synthetic polymeric intermediate (3) which is held  
 between the end bodies (1) through connecting  
 members (2).

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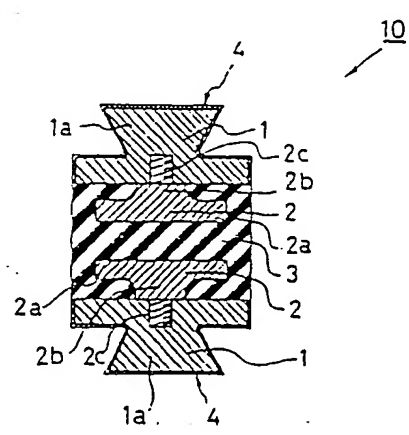


Fig.1

## ARTIFICIAL INTERVERTEBRAL DISC

## BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to an artificial intervertebral disc (movable vertebral body spacer) which can be implanted in a portion with a removed intervertebral disc to surgically treat a hernia of intervertebral disc or a injury of cervical vertebra or the like.

Description of Related Art

A hernia of intervertebral disc causes a patient to feel a severe pain due to the spinal nerves pressed by a central nucleus pulposus which is deviated by the regressive change of the intervertebral disc. There are several kinds of hernias of intervertebral disc, most of which are those of the lumbar part. There is also a hernia of intervertebral disc of the neck which is caused by an external wound resulting from a fall or a traffic accident or the like. It is also known that a hernia can be suddenly caused at night or at day time.

A hernia of intervertebral disc, if relatively slight, can be treated by fixing the intervertebral disc, but if it is serious, a surgical operation is necessary. In the conventional surgical treatment (operation), after the mal-intervertebral disc is removed, a bone is implanted, between upper and lower vertebral bodies. In the bone implantation, either a part of the iliac bone of the patient himself or herself or an artificial bone made of alumina or apatite is used. In these methods, however, the vertebral bodies which are naturally movable per se are immovably fixed and accordingly the vertebral bodies can not move relative to each other.

There is a long need of a development of a movable biomaterial which is implanted between the vertebral bodies.

Summary of the Invention

The primary object of the present invention is to eliminate the drawbacks of the prior art mentioned above by providing an artificial intervertebral disc exhibiting a biocompatibility, which disc can be easily implanted between the vertebral bodies, enables the vertebral bodies to move after implanting and does not cause a discomfort to the patient

due to the presence of the artificial intervertebral disc.

To achieve the object mentioned above, an artificial intervertebral disc according to the present invention has a pair of end bodies having apatite layer on the outer surfaces thereof and a medical synthetic polymeric intermediate having an elasticity which is held between the end bodies through connecting members.

Preferably, the end bodies of the artificial intervertebral disc according to one embodiment of the present invention are made of metal to increase the strength of the intervertebral disc. The end bodies are provided, on their outer surfaces, with apatite layers or coatings so as to exhibit a biocompatibility. The apatite layers can be formed, for example, by spraying. Preferably, the coefficients of thermal expansion of the apatite of the apatite layers and the metal of the end bodies are identical to each other. Titanium can be used as metal of which the end bodies are made.

The spraying can be performed, for example, by plasma spraying of apatite powders.

The apatite layers are preferably made of hydroxyapatite. It may be, however, not necessarily pure and contain apatites in which the hydroxy ions are substituted by fluorine or chlorine atoms and/or in which the calcium atoms are substituted by the other metal atoms.

Preferably, the thickness of the apatite layers is usually 0.1 mm-0.5 mm.

Preferably, the end bodies have projections which can be properly fitted into the vertebral bodies so as not to come out of the associated vertebral bodies.

In the present invention, the medical synthetic polymeric intermediate having an elasticity can be made of any rubber having a biocompatibility, such as silicone rubber, polyvinyl alcohol or polyurethane resin or the like. The medical synthetic polymer referred to herein has properties of chemical inactivity; no degeneration by the tissue-liquid, such as blood or humor; no vital reaction such as circumferential inflammation; no reaction to the foreign matter (implant), non-carcinogenesis; non allergic reaction; no decrease in tensile strength and in elasticity even after implanted in the vital body for a long period of time; no degeneration due to a disinfection such as boiling, chemicals or gas sterilization; and, simple and inexpensive machining and molding etc.

The connecting members for connecting the end bodies and the synthetic polymeric intermediate can be made of a material having a proper strength, such as titanium, stainless steel, or the

like.

### Brief Description of Drawings

The invention will be described below in detail with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view taken along the line I-I in Fig. 2, showing an artificial intervertebral disc according to one embodiment of the present invention;

Fig. 2 is a plan view of an artificial intervertebral disc according to one embodiment of the present invention; and,

Fig. 3 is a schematic view of an artificial intervertebral disc which is inserted between the vertebral bodies.

### Detailed Description of Embodiments

An artificial intervertebral disc 10 according to the present invention has a pair of end bodies 1 and a medical synthetic polymeric intermediate (member) 3 which is held between the end bodies 1 through connecting members 2. The medical synthetic polymeric intermediate 3 has a proper elasticity. The end bodies 1 are provided, on their outer surfaces, with apatite layers 4.

The end bodies 1 which are made of titanium are in the form of a rectangular parallelepiped and have outwardly extending center projections 1a in the form of an inverted frustrated cone. The projections 1a can be embedded in openings which will be formed in the vertebral bodies to oppose the adjacent vertebral bodies by the surgical operation. The projections 1a effectively prevent the end bodies 1 from coming out of the associated vertebral bodies.

The connecting members 2 which are made of titanium or stainless steel have embedded portions 2a which are in the form of a rectangular parallelepiped and which are slightly smaller than the end bodies 1, cylindrical projections 2b which are provided on the center portions of the embedded portions 2a to come into abutment with the associated end bodies 1, and screws (threaded portions) 2c which are provided on the projections 2b to be screwed in the associated end bodies 1.

The outer apatite layers 4 on the end bodies 1 can be formed, for example, by the plasma spraying per se known.

The thickness of the apatite layers 4 is preferably 0.1-0.5 mm.

A pair of end bodies 1 which are connected to the connecting members 2 by the respective

screws (threaded portions) 2c are spaced from and opposed to one another at a proper distance in a mold (not shown). After that, a synthetic rubber latex is fed-in between the end bodies 1 and is then cured to form medical synthetic polymeric intermediate 3 in which the connecting members 2 are embedded. In the artificial intervertebral disc 10 thus obtained, the medical synthetic polymeric intermediate 3 also occupies the spaces between the embedded portions 2a of the connecting members 2 and the associated end bodies 1. Since the embedded portions 2a are substantially analogous to and slightly smaller than the end bodies 1, the end bodies 1 are connected by the synthetic polymeric intermediate 3. Namely, there is no possibility of separation of the end bodies 1 from the associated connecting members 2 even after the artificial intervertebral disc 10 is embedded between the vertebral bodies.

The artificial intervertebral disc (spacer) 10 of the present invention is movable due to the flexibility of the medical synthetic polymeric intermediate 3. Accordingly, the medical synthetic polymeric intermediate 3 has a thickness enough to exhibit the flexibility. The thickness of the medical synthetic polymeric intermediate 3 which depends on the total size of the spacer 10 and the size of the connecting members 2 etc. is usually 5-35mm and preferably 10-30 mm.

Fig. 3 schematically shows an artificial intervertebral disc 10 which is inserted between the adjacent vertebral bodies 11 of the lumbar part or the neck. The adjacent vertebral bodies 11 have openings 11a formed therein in which the associated projections 1a of the end bodies 1 of the artificial intervertebral disc 10 are embedded. Numeral 12 designates sound intervertebral discs.

Since the medical synthetic polymeric intermediate 3 having a flexibility is held between the end bodies 1, the artificial intervertebral disc according to the present invention can be elastically deformed in accordance with the movement of the vertebral bodies 11. As a result, the spinal cord portion in which the artificial intervertebral disc 10 of the present invention is implanted is movable and accordingly does not have an adverse influence on the sound vertebral bodies. In particular, the artificial intervertebral disc 10 of the present invention can be advantageously implanted in the neck, so that the patient can move the neck without feeling discomfort. Furthermore, since the artificial intervertebral disc of the present invention has the apatite layers 4 provided on the outer surfaces of the end bodies 1 to provide a biocompatibility, and since the medical synthetic polymeric intermediate 3 is formed by a molded rubber, no adverse influence is given to the vital tissues and functions.

It should be noted that the shapes of the end

bodies 1 and the connecting members 2 are not limited to those illustrated in the drawings and can be modified without deviating from the scope of protection of the invention.

## Claims

1. An artificial intervertebral disc (10) comprising a pair of end bodies (1) which are provided, on their outer surfaces, with apatite layers (4) and a medical synthetic polymeric intermediate (3) which is held between the end bodies (1) through connecting members (2). 10
2. An artificial intervertebral disc (10) according to claim 1, wherein said end bodies (1) are made of titanium. 15
3. An artificial intervertebral disc (10) according to claim 1, wherein said end bodies (1) are made of stainless steel. 20
4. An artificial intervertebral disc (10) according to one of claims 1 to 3, wherein said connecting members (2) are made of stainless steel.
5. An artificial intervertebral disc (10) according to one of claims 1 to 3, wherein said connecting members (2) are made of titanium. 25
6. An artificial intervertebral disc (10) according to one of claims 1 to 5, wherein said connecting members (2) have screws (2c) for connecting the same to the associated end bodies (1). 30
7. An artificial intervertebral disc (10) to be implanted between the vertebral bodies (11), according to one of claims 1 to 6, wherein said end bodies (1) have projections (1a) which can be engaged in the associated vertebral bodies (11). 35
8. An artificial intervertebral disc (10) according to one of claims 1 to 7, wherein said medical synthetic polymeric intermediate (3) has an elasticity.
9. An artificial intervertebral disc (10) according to claim 8, wherein said medical synthetic polymeric intermediate (3) is made of a material selected from silicone rubber, polyvinyl alcohol, and polyurethane. 40
10. An artificial intervertebral disc (10) according to one of claims 1 to 9, wherein said apatite layers (4) are formed by plasma spraying. 45
11. An artificial intervertebral disc (10) according to one of claims 1 to 10, wherein said apatite layers (4) and said end bodies (1) are made of materials having coefficients of thermal expansion substantially identical to each other. 50

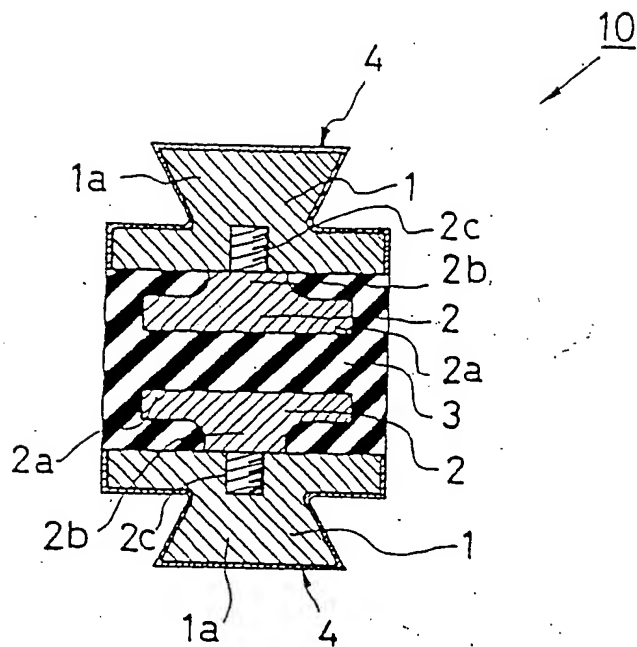


Fig. 1

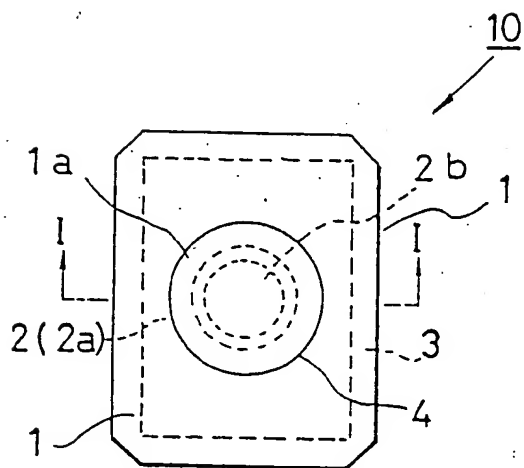


Fig. 2

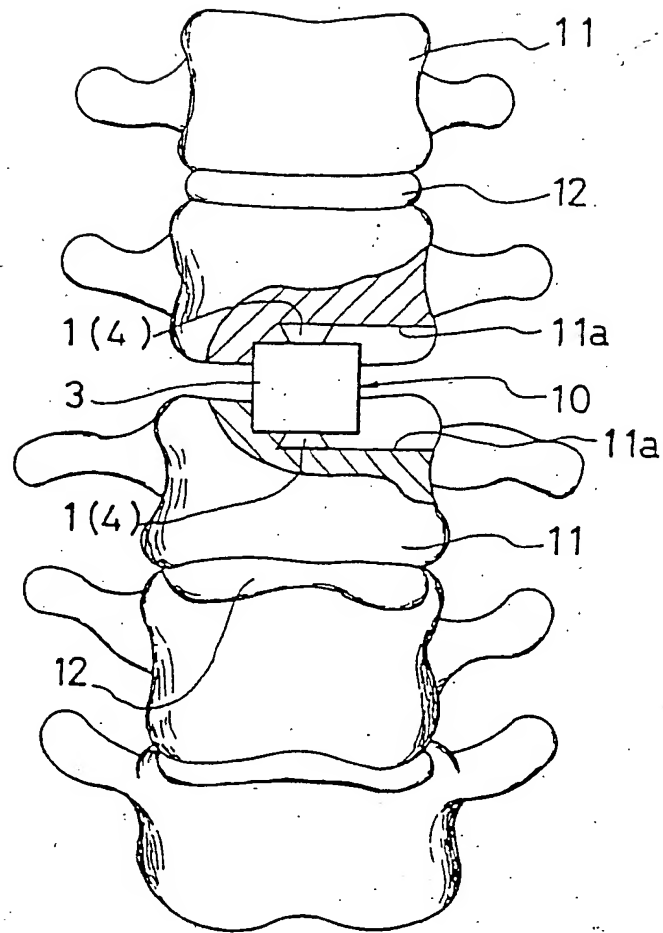


Fig. 3



EP 88 11 9477

| DOCUMENTS CONSIDERED TO BE RELEVANT   |  |  |  |
|---|--|--|--|
| Category  | Citation of document with indication, where appropriate, of relevant passages  | Relevant to claim  | CLASSIFICATION OF THE APPLICATION (Int. Cl. 4) |
| A   | EP-A-0 176 728 (HUMBOLDT-UNIVERSITÄT)<br>* Page 6, line 27 - page 7, line 14;<br>page 9, lines 5-10; figures 1,2,11,12 * | 1-3,6,7  | A 61 F 2/44                                    |
| A   | US-A-4 553 273 (K. WU)<br>* Column 1, line 51 - column 2, line 24; figures *   | 1,4,6  |  |
| A   | DE-A-2 263 842 (HOFFMANN-DAIMLER)<br>* Page 14, lines 1-4; page 15, line 13 - page 16, line 6; claim 1; figures 1,5 *    | 1,8,9  |  |
| A   | FR-A-2 336 913 (SUMITOMO)<br>* Page 1, lines 1-35; claims 1,13,17 *  | 1-3,10   |  |
| A   | EP-A-0 202 908 (SUMITOMO)<br>* Page 1, lines 2-19; claims 1,6,7 *  | 1,2,10   |  |
| A   | DE-A-2 804 936 (SULZER)<br>* Page 4, line 8 - page 5, line 11; figures 1-4 *   | 1,7  | TECHNICAL FIELDS<br>SEARCHED (Int. Cl. 4)      |
| A   | US-A-3 867 728 (STUBSTAD)<br>* Column 7, lines 39-59; column 9, lines 63-67; figures 1-6 *                               | 8,9  | A 61 F   |
| A   | US-A-4 044 170 (SCHARBACH)<br>* Column 1, line 53 - column 2, line 35 *  | 11   |  |
| A   | DE-A-3 023 353 (SULZER)  |  |  |
| A   | US-A-3 875 595 (FRONING)   |  |  |
| The present search report has been drawn up for all claims  |  |  |  |
| Place of search<br>THE HAGUE  |  | Date of completion of the search<br>27-02-1989   | Examiner<br>KLEIN C.                           |
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